# PATENT SPECIFICATION

702,578

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## COMPLETE SPECIFICATION

## Improvements in Methods and Apparatus for Testing the Liquid Content of Substances

We, CARL WILHELM BRABENDER, a German National, of Calhoun Beach Club Hotel, and WILLIAM RAY COYNE, an American National, of 220, Sheridan Avenue South, both of Minneapolis, Minnesota, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improvements in methods of and apparatus for determining the liquid content of substances for use in a manufacturing process.

An object of the invention is to provide a method and apparatus for rapidly evaporating liquids from substances without oxidizing some of the substance itself, and for determining the resultant loss of weight by weighing the same before and after such evaporation under controlled conditions.

The shortest hitherto recognised method for liquid content determinations of material such as, by way of example, flour to be used in the making of bread or for mixture with sand in metal casting, has required a drying period of approximately one hour at a temperature of about 130°C. The shortest non-recognised method has required heating at temperatures in the neighbourhood of 160°C. for a period of twenty minutes or longer. Each of these periods is objectionably long, for a great deal of time is necessarily consumed when using these methods in determining the moisture content of a large number of samples. Anyone skilled in the art would ordinarily expect that when a thin layer of material such as flour is subjected to infra-red radiation, the penetration of such radiation would be more than sufficient to dry the material effectively.

It has been discovered, however, that this is not the case and that the length of time required to dry a given sample may be substantially reduced.

According to this invention, the liquid content of substances to be used in a manufacturing process is determined by subjecting a sample of the substance to the action of heat while agitating the same for a predetermined amount of time and weighing the sample before and after such heat and simultaneous agitation treatment.

An apparatus according to the invention for determining the liquid content of a substance is provided with agitating mechanism mounted within an oven to effect frequent change of exposed surface of a substance contained in a pan supported within such oven, and the liquid content of which is to be determined, a weighing device being adapted to engage said pan to weigh the same while such pan is disposed within the oven.

The invention is further described with reference to the accompanying drawings, wherein like reference characters refer to the same or similar parts throughout the several views.

In the drawings:—

Fig. 1 is a front elevational view of one embodiment of the apparatus of the invention with a portion of the oven broken away to show the weighing mechanism in operation;

Fig. 2 is a top plan view of the same with the top of the oven broken away in part to show the interior of the oven;

Fig. 3 is a vertical sectional view taken along line 3—3 of Fig. 2;

Fig. 4 is a horizontal sectional view taken along line 4—4 of Fig. 3;

Fig. 5 is a horizontal sectional view taken along 5—5 of Fig. 3;

Fig. 6 is a bottom view of one of the pans;

Fig. 7 is a vertical sectional view of one of the pans;

Fig. 8 is a wiring diagram of the electric

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connections utilized in the embodiment shown.

One embodiment of the invention includes, as shown in Fig. 1-8, a unit consisting of a frame indicated generally as 10 having a plurality of vertically adjustable legs 11, side plates 12, a lower plate 13, and an upper plate 14 extending between the legs 11. The upper plate 14, as shown, is rigidly secured to the upper ends of the legs 11 and the lower plate 13 is rigidly mounted by welding or any other suitable means between these legs.

Fixedly mounted upon the frame 10 in superimposed but spaced relation is an oven indicated generally as 15. This oven 15 is rigidly secured to the upper plate 14 by bolts 16 and is maintained in spaced relation therefrom by spacing collars 17. These bolts 16 are disposed somewhat centrally of the upper plate 14 and of the oven 15. The oven 15 is provided with a bottom wall 18 within which we have formed a plurality of equi-spaced apartures 18*a* adjacent its peripheral portions. As shown, these apertures as six in number but they may, of course, be utilized in any number desired. The top wall 19 of the oven is provided with a plurality of adjustable ventilators 20. The front side wall 21 is provided with a window 22 and a thermometer 23 which is adapted to indicate the temperature of the air within the oven 15.

Mounted in each of the apertures 18*a* with the exception of one indicated as 18*b* in Fig. 1, is a bearing 24 having mounted therein a rotatable shaft 25. Each of these shafts 25 is provided at its lower end with a drive gear 26 and at its upper end with a support plate 27. Each of the support plates 27 has a central recess 27*a* (Fig. 4) and peripheral recesses 27*b*. A drive chain 28 is driven by a motor M to rotate the shafts 25 with their plates 27.

Rigidly mounted in upright position upon the central portion of the lower plate 13 is a hollow shaft 29. This hollow shaft 29 extends upwardly through the upper plate 14 and through the bottom wall 18 of the oven 15 to a point adjacent the top wall 19 of the oven. At its upper end a mounting plate 30 is rigidly secured thereto and this mounting plate carries a pair of electric heating elements 31 and a plurality of infra-red lamps 32. One of these lamps 32 is disposed directly above each of the support plates 27.

Mounted on the hollow shaft 29 in free sliding relation with respect thereto is an inner sleeve 33 which extends upwardly to a point spaced below the mounting plate 30. Fixedly secured to the lower end portion of the sleeve 33 is a shaft collar 34 which has a pair of spaced shoulders 35 thereon. A shift lever 36 is pivotally mounted on a mounting bracket 37 which in turn is mounted upon the front side plate 12, the arms of which extend inwardly to engage the collar 34 between the shoulder members 35.

Mounted on the inner sleeve 33 in free sliding relation with respect thereto is an outer sleeve 39. This outer sleeve 39 is considerably shorter than the inner sleeve 33 and has fixedly mounted on its lower end a lock plate 40, the peripheral edge of which has formed therein a plurality of recesses 41 as best shown in Fig. 5. The number of these recesses 41 is greater by one than the number of lamps 32 or support plates 27. The recesses 41 co-operate with a lock post 42 which is rigidly mounted in upstanding position upon the lower plate 13 of the frame 10. These recesses 41 also co-operate with a spring controlled pin 43 mounted in guides on a bracket on the frame 10 and frictionally engaging one or other of the recesses 41 of the plate 40 on the outer sleeve 39 to hold this against rotational movement about its axis. This is best shown in Fig. 5.

Mounted on the outer sleeve 39 in spaced relation to and above the lock plate 40 is a bevel gear 44. This bevel gear 44 is fixedly secured to the sleeve 39 and positioned below a complementary bevel gear 45 which is formed on the inner end of a manually operated drive shaft 46. The drive shaft 46, as shown, is mounted for free rotational movement about its longitudinal axis within a depending bearing 47 which is rigidly secured to the upper plate 14 of the frame 10. As shown, the drive shaft 46 is provided with a handle 48. Also fixedly mounted on the outer sleeve 39 just above the co-operating bevel gear 45 is a retainer disc 49. This retainer disc 49 has a plurality of spaced depending teeth 50 which are disposed so as to engage the teeth of the bevel gear 45 when the retainer disc is in lowered position.

As shown best in Fig. 3, the sleeves 33 and 39 extend upwardly through the upper plate 14 and the bottom wall 18 of the oven into the interior of the oven itself. Fixedly mounted on the outer sleeve 39 above the bottom wall 18 is a collar 51 which has secured thereto a pan holder or tray 52. This pan holder or tray 52 is provided with a plurality of equally spaced apertures 53 exceeding in number by one the number of support plates 27. The apertures 53 are disposed immediately above the support plates 27 and are each of sufficient diameter to snugly receive therein a pan 54. Each of the pans 54, as best shown in Figs. 6 and 7, is provided with a centering pin 55 and a drive pin 56. The centering pin 55 is adapted to be received

into the centering recess 27*a* of a support plate 27 and the drive pin 56 is adapted to be received in the recess 27*b* of that plate. Each of the pans 54 has a vertical side wall 54*a* which flares outwardly as at 54*b*.

Fixedly mounted on the sleeve 33 above the pan holder 52 is a mounting collar 57. Extending outwardly from this mounting collar 57 is a plurality of depending stirring arms 58. These arms equal in number the number of support plates 27 and are arranged to extend downwardly to a point directly above such plates so as to extend within the confines of a pan 54 when such pan is supported by the plate 27. As best shown in Fig. 3, the stirring arms 58 extend outwardly to a point slightly beyond the centre of each pan 54 and depend downwardly to a point where they will be in very close proximity to the bottom of the pan. The inner end of each stirring arm 58 extends sufficiently far toward the side of the pan to insure that all of the contents of the pan will be engaged and agitated when the pan 54 is rotated. The stirring arms 58 are preferably shaped as shown.

Mounted on the front side plate of the frame 10 is a weighing mechanism indicated generally as W which is encased in a substantially closed compartment to prevent air currents from influencing the same. This weighing machanism W is comprised of a steelyard 59 which is pivoted as at 60 and which is provided at its right hand end, as viewed in Fig. 1, with a plate 61 bearing a plurality of upstanding rods 62 which pass through apertures 18*b* of the tray or pan holder 52, and a dependent counter weight 63. As shown, the plate 61 is pivotally mounted on the right hand end of the steelyard and carries an indicator 64 which will provide a direct scale reading on the moisture percentage scale 65. The steelyard 59 is provided, as shown, with a counterbar 66.

Pivotally mounted on the inside of the front side plate of the frame 10 is a lever 67 which has a cam 68 on its forward end and a control arm 69 midway along its length and projecting to one side to engage the right hand end of the steelyard 59 to withdraw the rods 62 from the apertures 18*b* in the pan holder or tray 52. A timing mechanism indicated generally as T is also provided to furnish a signal when the infra-red lamps have been heating for a desired period.

Fig. 8 shows a diagrammatical view of the electrical circuit used in the device. The infra-red lamps 32 and the heating elements 31 are supplied with electrictiy by wires which extend therefrom downwardly through the hollow shaft 29. The source of electricty indicated generally as S in Fig. 8 provides the necessary current for the motor M when a switch 70 is moved to closed position. It also provides, through these wires, the necessary current for the timing mechanism T and the infra-red lamps 32 when a switch 71 is closed. The heaters 31 are connected in a manner such that either one or both may be heated at the same time by merely throwing in a double throw switch 72 into the desired position. As shown, in Fig. 8 neither of the heating elements 31 would be energized. As the switch 72 is thrown to its lower position, only the upper of the two heating elements shown in Fig. 8 will be energized. If the switch 72 is moved to its upper position as shown in Fig. 8, both of the heating elements will receive current.

In operation, the substances having the unknown liquid content are weighed out on a separate scale in desired weights such as 10 grams, and upon separate pans. The pans 54 containing the desired amount of the substance are thereafter inserted into the oven 15 and positioned on their respective support plates 27. In order to do this, of course, the mounting collar 57 and the stirring arms 58 must be in the raised position. To move these arms 58 to raised position, the operator depresses the shift lever 36 to cause its fork 38 to move the shift collar 34 upwardly. The shift collar 34 will move upwardly through the sliding action of the sleeve 33 with respect to the hollow shaft 29 until the upper end of the collar 34 engages the lower surface of the lock plate 40. As it does this, the mounting collar 57 will move upwardly with the sleeve 33 to a level intermediate the levels shown in solid lines and in broken lines in Fig. 3.

As the inner sleeve 33 moves upwardly carrying the outer sleeve 39 therewith, the lock plate 40, the bevel gears 44, the retainer disc 49, and the pan holder or tray 52 are carried upwardly because of their fixed mountings on the outer sleeve 39. Thus it can be seen that when the shift lever 36 has its outer end forced downwardly to its lower limit, the mounting collar 57 and the stirring arms 58 will be disposed in the position shown in broken lines in Fig. 3. At the same time, the pan holder or tray 52 will be moved upwardly to lift the respective pans 54 free from their respective support plates 24. At the same time, the retainer disc 49 will be lifted free of the bevel gears 45 and the bevel gears 44 will be brought into engaging position with the bevel gears 45. Meanwhile the lock plate 40 will be forced upwardly to a position free of the lock post 42. The pans 54 may then be inserted into apertures 53 of the tray 52 and the

moisture determining operation is ready to commence.

When the shift lever 36 is moved upwardly, the collar 34 is drawn downwardly and the respective parts once again assume the positions shown in solid lines in Fig. 3. While in these positions, the lock post 42 and the spring pawl 43 serve to lock the outer sleeve 39 and the pan holder or tray 52 from rotating on their axes. At the same time, the depending teeth 50 on the retainer disc 49 will engage the teeth of the bevel gear 45 to insure that this gear will at all times be properly oriented to receive the bevel gear 44 for co-operative action when the latter is raised sufficiently to engage the gear 45.

Prior to starting the motor M, it is desirable to heat the oven to the desired temperature. To facilitate such heating, the heating elements 31 may be utilized as described above. After the desired temperature has been reached, these elements may be cut out while the infra-red lamps 32 are permitted to continue to burn.

By closing the switch 70, the motor M is started and the drive chain 28 commences to drive the shafts 25 and their respective support plates 27. As each support plate rotates, the respective pan 54 will also rotate due to engagement of the drive pin 56 with a recess 27*b* in the support plate. It should be noted that the lowering of the collar 34 permits the pan holder or tray 52 to move downwardly to a position such that the pans 54 will rest upon their respective support plates 27 and that it also permits the respective stirring arms 58 to be lowered to operative position within the confides of the pan 54.

As the pans 54 are rotated by their respective support plates 27, the substances contained therein will be rapidly agitated by the lower horizontal portions of the arms 58. It should be noted that the lower horizontal portion of each arm 58 extends to a point slightly beyond the centre of each pan to ensure that all of the substances will be engaged by the arm. Since the lower horizontal portion of the arm is disposed in close proximity to the bottom of the pan 54, the whole charge therein will be disturbed and the exposed surface thereof in consequence will be repeatedly changed. This repeated changing of the exposed surface of the substance which is exposed to the heat generated by the infra-red lamps 32 permits the use of considerably higher temperatures than would otherwise be possible and facilitates the rapid evaporation of the liquids such as water contained in such substances. Without such stirring, a relatively low heat must be used for such drying process to avoid scorching of the substances contained within the pans. This is imperative since any scorching which takes place necessarily means that oxidation to a certain extent has occurred. Such oxidation always is accompanied by a corresponding loss of weight of the substance itself and thus would introduce substantial inaccuracies.

The rotation of the pans 54 with respect to the stirring arms 58 provides a stirring action within the substances contained in the pans which strongly resembles ploughing. Since the exposed surface of the substance will relatively cool when brought from below the heap by the action of the stirring arms, and since it will be exposed to the infra-red lamp only briefly before being again ploughed under, a much more intense heat may be used without serious danger of scorching. Thus it can be seen that the rate of evaporation of liquids from such substances will be greatly increased as a direct result of the mixing and the uniform and permeating heating throughout the mass of the substance.

After the substances contained in the pans 54 have been subjected to this repeated agitation beneath the infra-red lamps 32 for a period of five to ten minutes, by way of example, it has been found that substantially all of the moisture contained therein will have been evaporated. In fact, the errors involved in comparison with methods wherein the substances have been dried at a slower rate for a period of one hour or more are less than 0.1%. The respective pans and their contents are then ready for weighing. To determine the loss of weight resulting from the driving operation, the shift lever 36 is again swung to its downward position so that all of the pans 54 will be supported by the pan holder 52. By turning the handle 48, the bevel gear 45 will rotate the bevel gear 44 and, consequently, the pan holder 52, to a position where the pan desired to be weighed will be disposed directly above the opening through which the rods 62 may project upwardly. When the pan is at this point, the lever 67 is moved to its downward position to permit the steelyard 59 to perform the weighing operation. When the lever arm 67 is forced downwardly the control arm 69 will go upwardly and the rods 62 will extend upwardly through the aperture 18*b* in the tray 52 to elevate the pan 54 which has been just previously disposed thereabove. The percentage of moisture of the pan's contents will be indicated directly on the direct reading scale 65. At the same time, as the outer end of the lever 67 is moved downwardly, the cam 68 on its end is brought behind the spring pin 43 to lock the same in position. Thus the operator is doubly insured against any inadvertent turning of the tray 52 with

consequent injury to the steelyard 39.

The operation described above may be repeated for each of the respective pans. Thus it can be seen that the device may be used as desired, either first weighing out five samples of the desired weight and drying them all simultaneously and weighing them successively, or by placing one pan within the oven after each weighing operation to replace the pan just previously weighed and removed so as to make the operation continuous.

It should be noted that each of the stirring arms 58 when raised to its uppermost position comes in contact with its respective infra-red lamp 32. This contact jars the arm 58 slightly and insures that none of the substances, the moisture content of which is to be determined, clings to the arm 58 to cause inaccuracies in the determination.

It has been found that temperatures ranging between 250 degrees to 350 degrees Fahrenheit within the oven 15 are preferable for these determinations in the case, for instance, of testing of flour. The heating elements 31 are utilized to bring the temperatures of the oven up to the desired level within a relatively short period of time when the determinations are being commenced. After the temperatures has once reached the desired level, the lamps 32 will maintain the temperature level sufficiently without the use of the heating elements 31.

The agitation of the contents of the pan 54 is primarily responsible for the increased rate of evaporation made possible with this device. It has been found that such agitation permits the use of higher temperatures during the drying operations. For example, whereas previously a substance could only be heated at a given temperature for three minutes without scorching, it is now possible to heat the same subtance for a period of thirty minutes without scorching as a result of the repeated changes made in its exposed surface due to its constant agitation. This agitation may be effected otherwise than by stirring, as for instance by subjecting the same to vibratory movements.

It may be noted that the determinations are made with the respective pans remaining within the interior of the oven itself so as to insure maximum accuracy in the determinations. In addition, while the weighing operation is performed on a sample, the remaining samples can be in process of being dried, within the apparatus.

What we claim is:—

1. A method of testing the liquid content of substances to be used in a manufacturing process consisting in subjecting a sample of the substance to the action of heat while agitating the same for a predetermined amount of time and weighing the sample before and after such heat and simultaneous agitation treatment.

2. A liquid content-determining apparatus in which agitating mechanism is mounted within an oven to effect a frequent change of exposed surface of a substance contained in a pan supported within such oven and the liquid content of which is to be determined, a weighing device being adapted to engage said pan to weigh the same while such pan is disposed within the oven.

3. Liquid content-determining apparatus as claimed in Claim 2, in which means are provided for supporting and revolving within the oven the pan containing the substance the liquid content of which is to be determined.

4. A liquid content-determining apparatus as claimed in Claim 2, in which the weighing device is disposed outside said oven and extends into said oven to engage the pan to weigh the same while disposed within said oven.

5. A liquid content-determining apparatus as claimed in Claim 2, in which a revoluble pan-holder is disposed within the oven and is adapted to support a plurality of pans containing substances the liquid content of which is to be determined, means being provided to revolve the holder to selectively position any one of such pans in a predetermined position for weighing.

6. A liquid content-determining apparatus as claimed in Claim 5, in which the agitating mechanism comprises stirring arms mounted for limited vertical movement relative to said pan-holder.

7. A liquid content-determining apparatus as claimed in Claim 5, in which the agitating mechanism comprises stirring arms, each of which extends from a point adjacent the side wall of a pan to a point beyond the centre of the same whereby efficient stirring of all the substance contained within each pan may be assured.

8. A liquid content-determining apparatus as claimed in Claim 5, in which the revoluble pan holder within the oven is provided with holes adapted to support a plurality of pans containing substances the liquid content of which is to be determined, the revolution of said pan holder being arrestable at a predetermined position, at which a pan is engaged and elevated by the weighing device, while a plurality of stirring arms are mounted for vertical movement above each of such pans so that they may be lowered into the respective pan to engage and stir the contents thereof.

9. A method of testing the liquid content of substances as hereinbefore particularly

described.

10. A liquid content - determining apparatus constructed as hereinbefore particularly described with reference to the accompanying drawings.

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Fig. 1

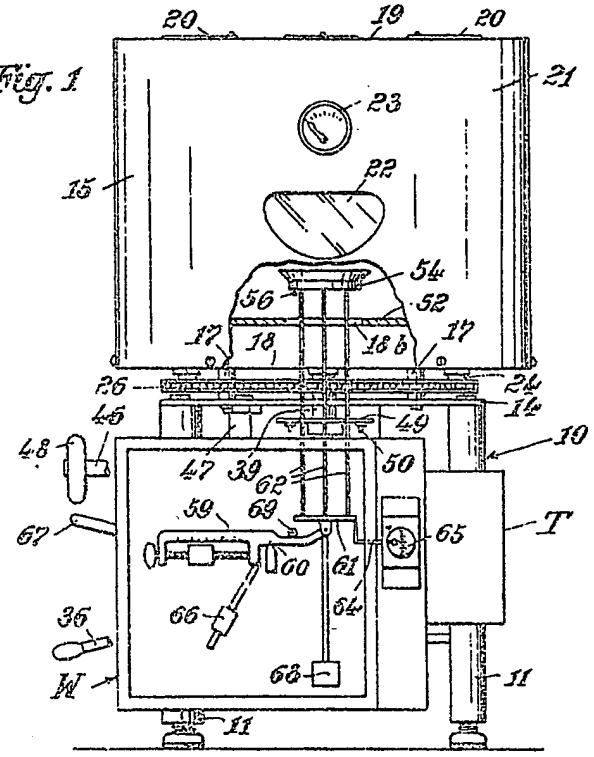
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Fig. 2

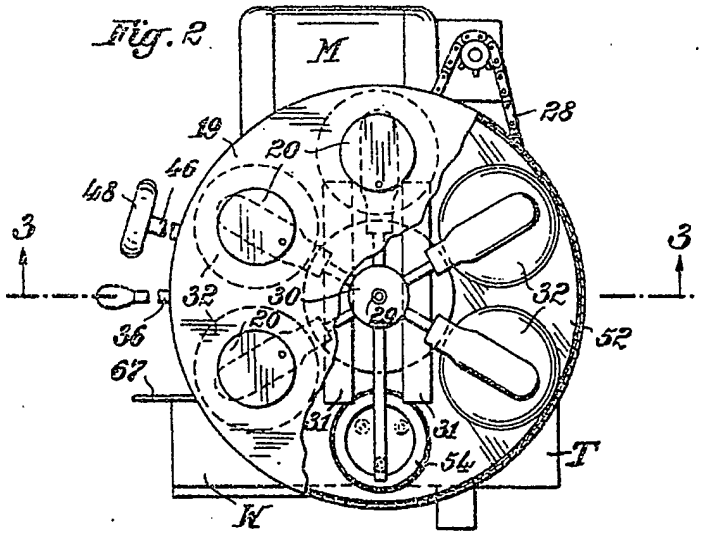
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Fig. 3

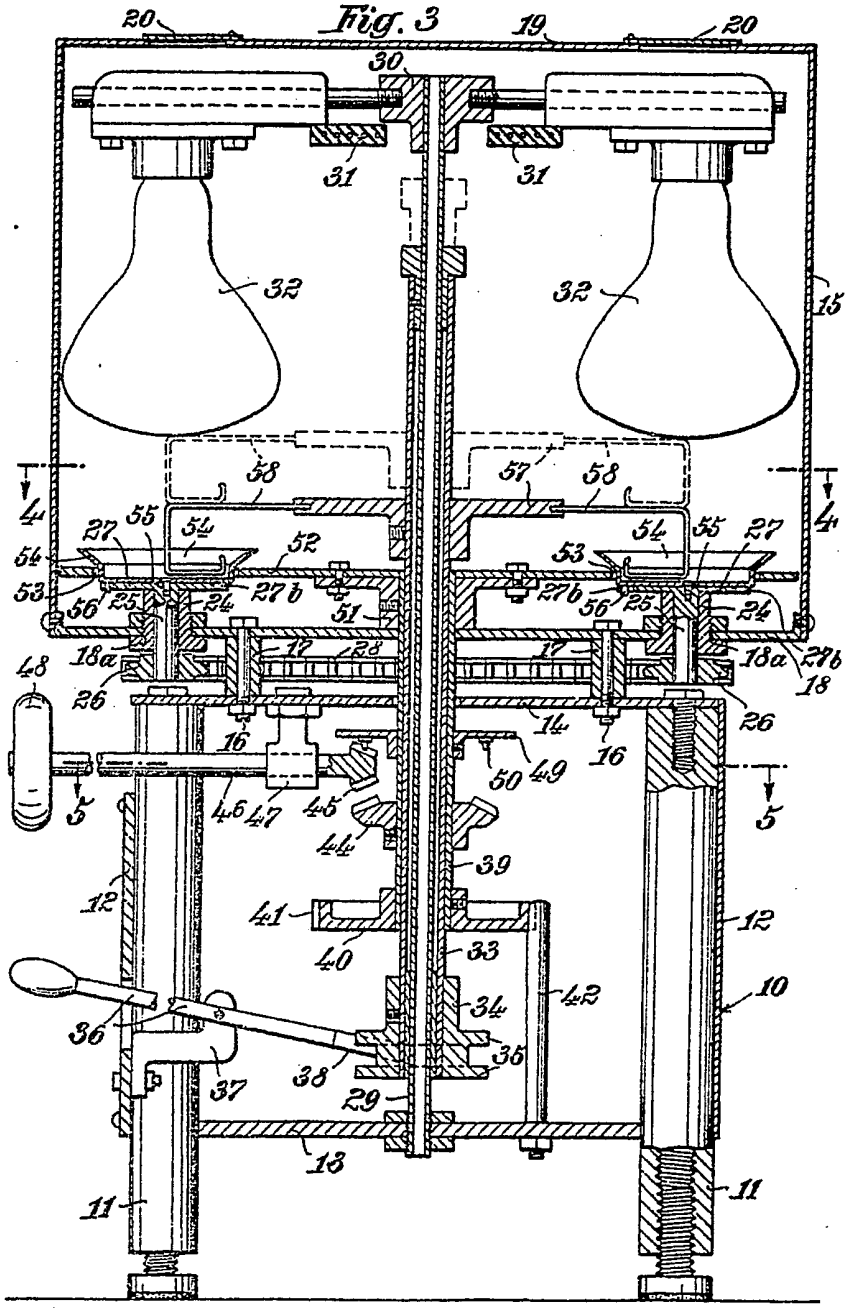

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Fig. 1

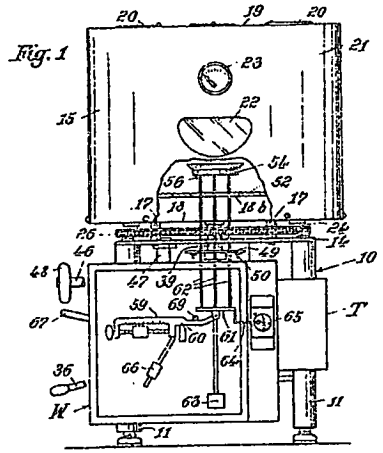

Fig. 2

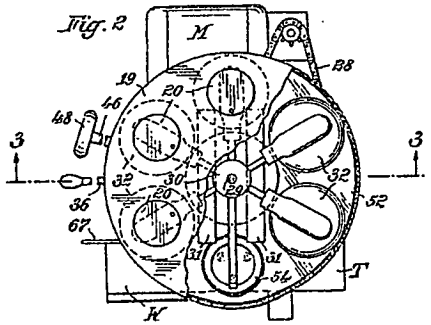

Fig. 3

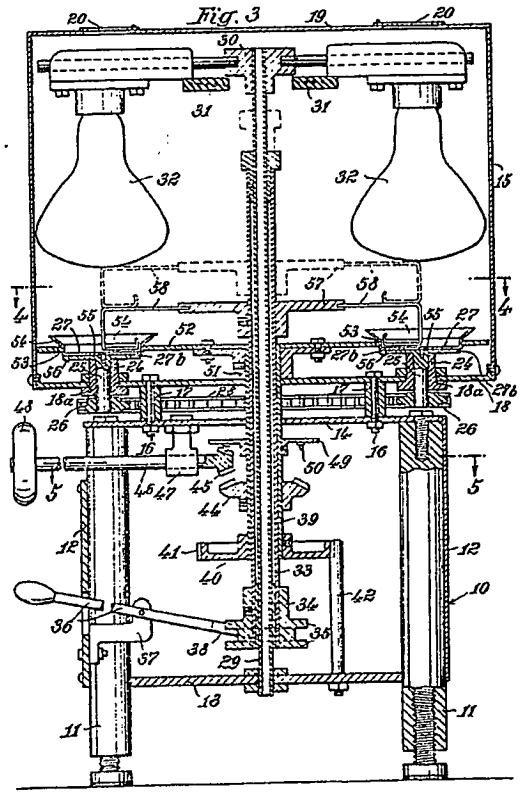

Fig. 4

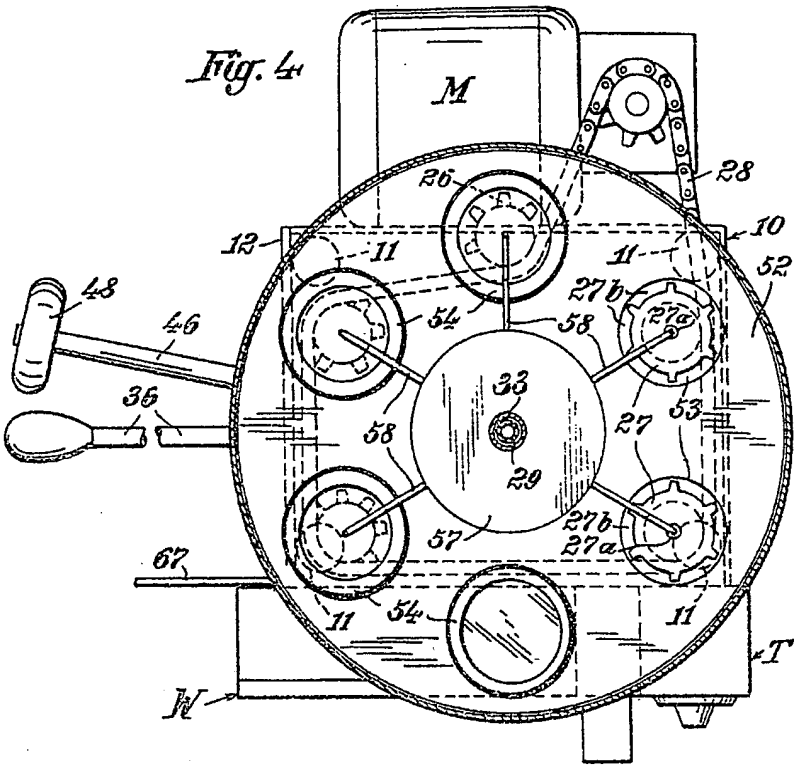


Fig. 6

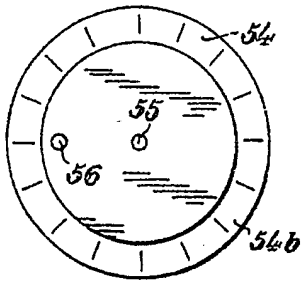


Fig. 7

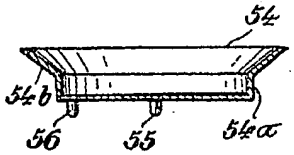

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Fig. 5

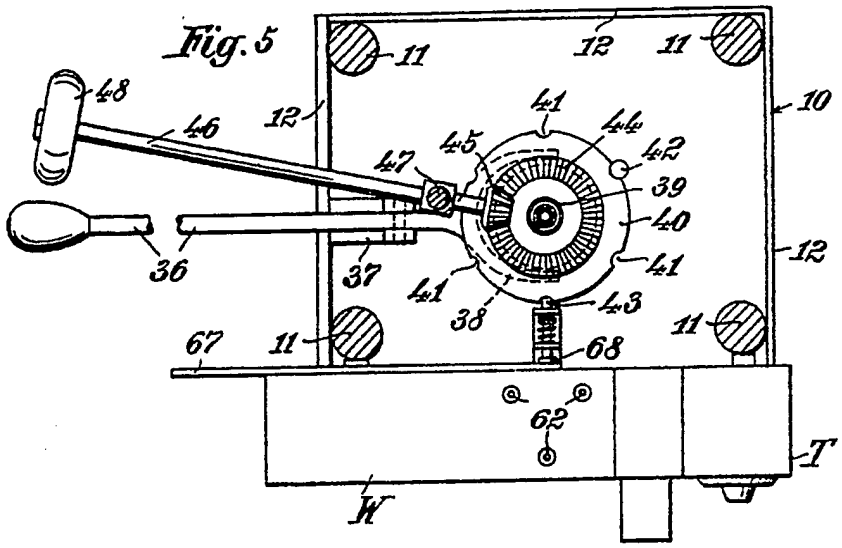


Fig. 8